Measurement of neutron induced fission cross sections of Cm nuclides

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STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

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Belgian Science Policy

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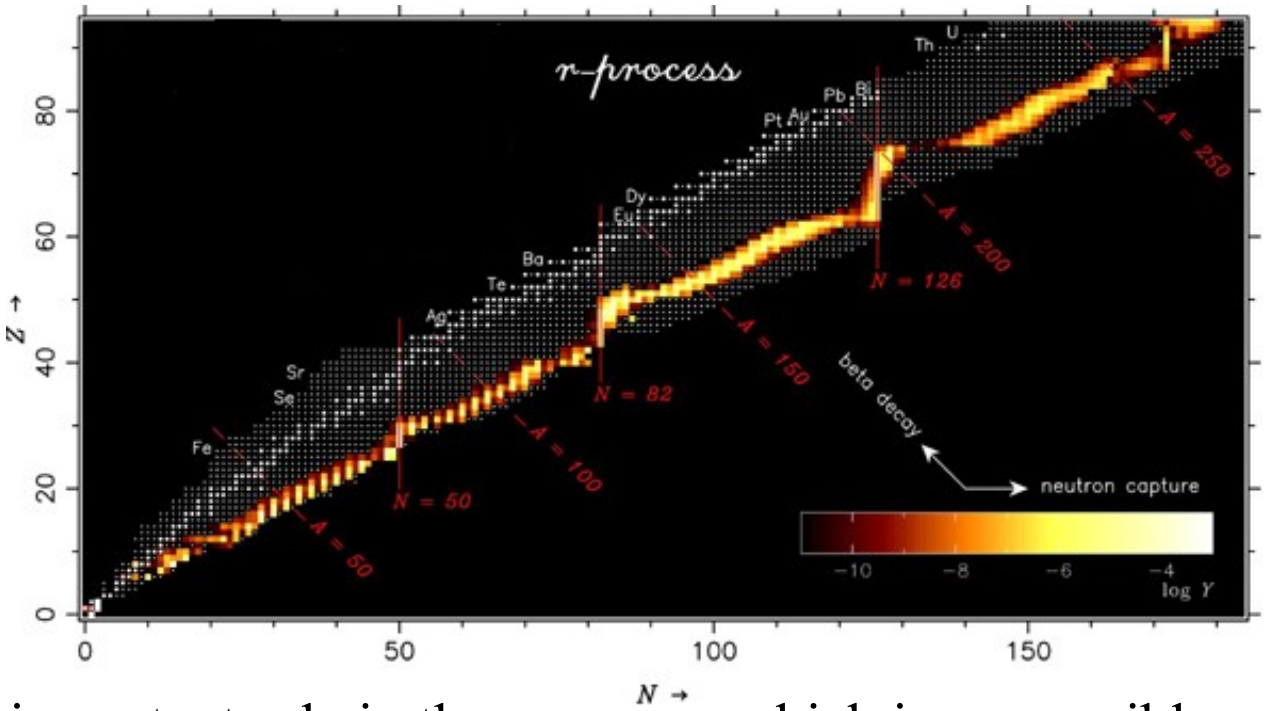
Outline

- Motivations
- Available information
- Experimental work

Motivations. Nuclear Astrophysics

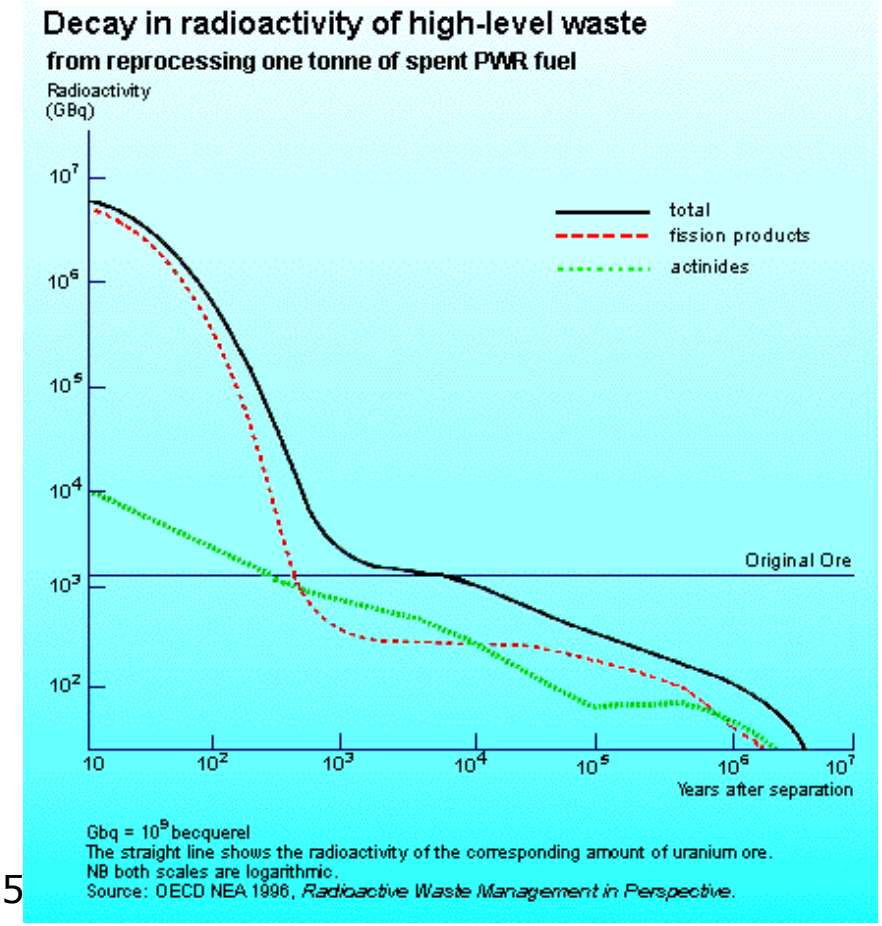
r-process nucleo-synthesis and fission



Fission plays an important role in the r-process which is responsible not only for the yields of transuranium isotopes, but may have a strong influence on the formation of the majority of heavy nuclei due to fission recycling.

Motivations. Nuclear Reactors Physics

- Cm nuclei - present in the Nuclear Waste
- Accurate (n,f) cross sections required for nuclear waste transmutation calculations



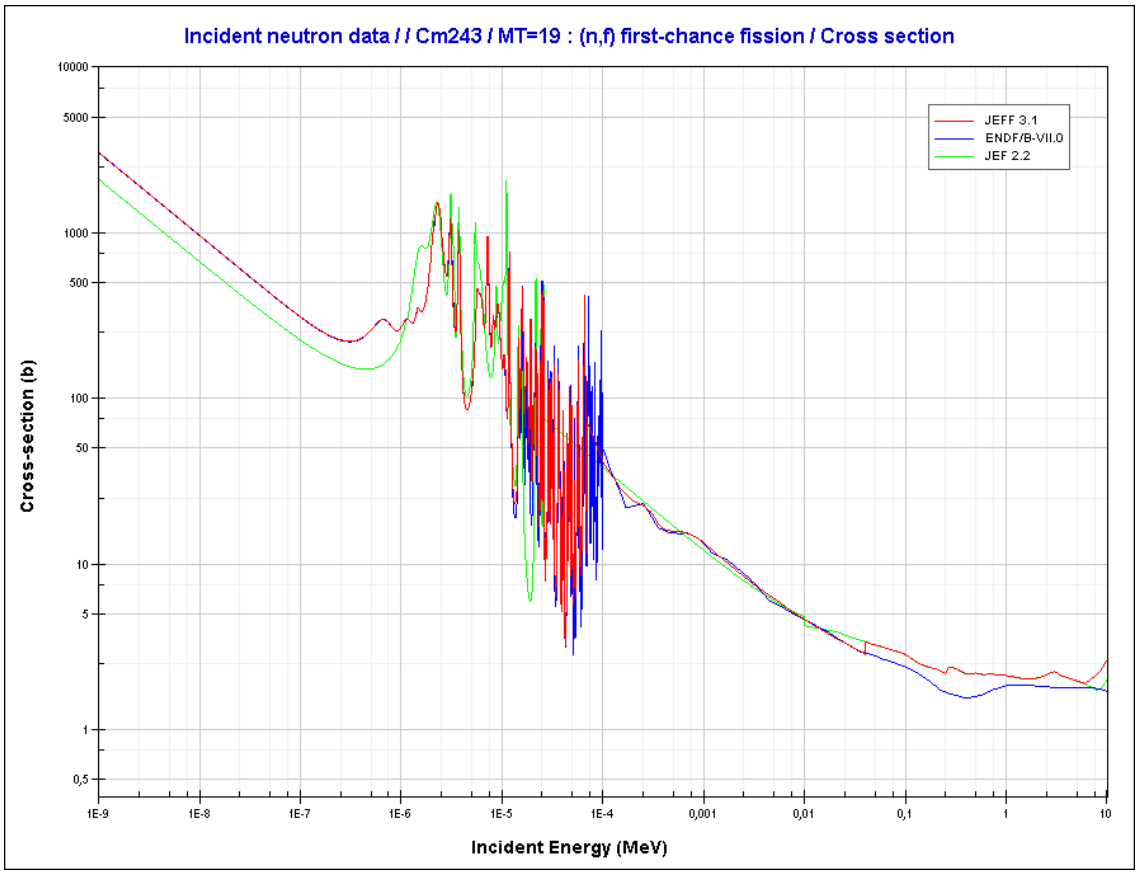
Comparison of Existing Data

Cross-section at $E_n = 25$ *meV*

(JEFF 3.1)
617.94 b

(ENDF/B-VII.0)
613.83 b

(JEF 2.2)
431.67 b



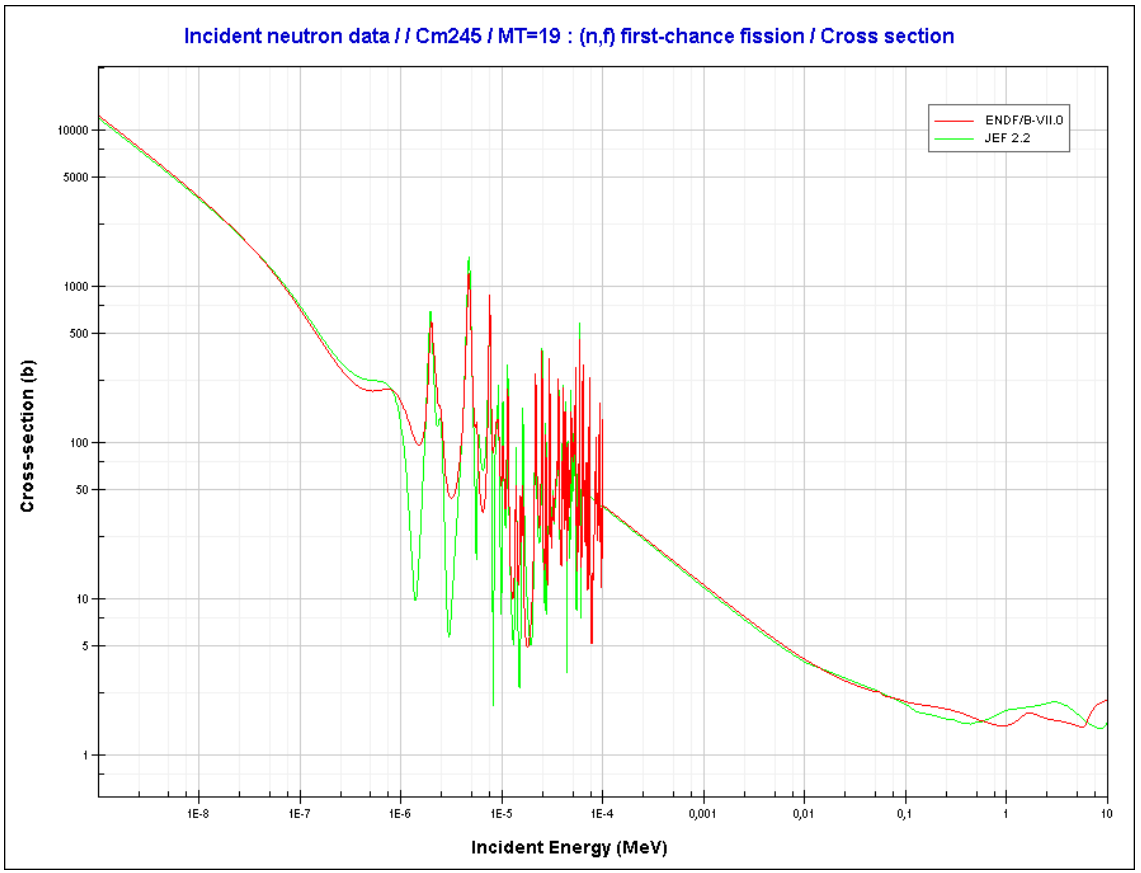
^{243}Cm (n,f) first-chance fission

Comparison of Existing Data

Cross-section at $E_n = 25$ *meV*

(ENDF/B-VII.0)
2150.5 b

(JEF 2.2)
2139.5 b



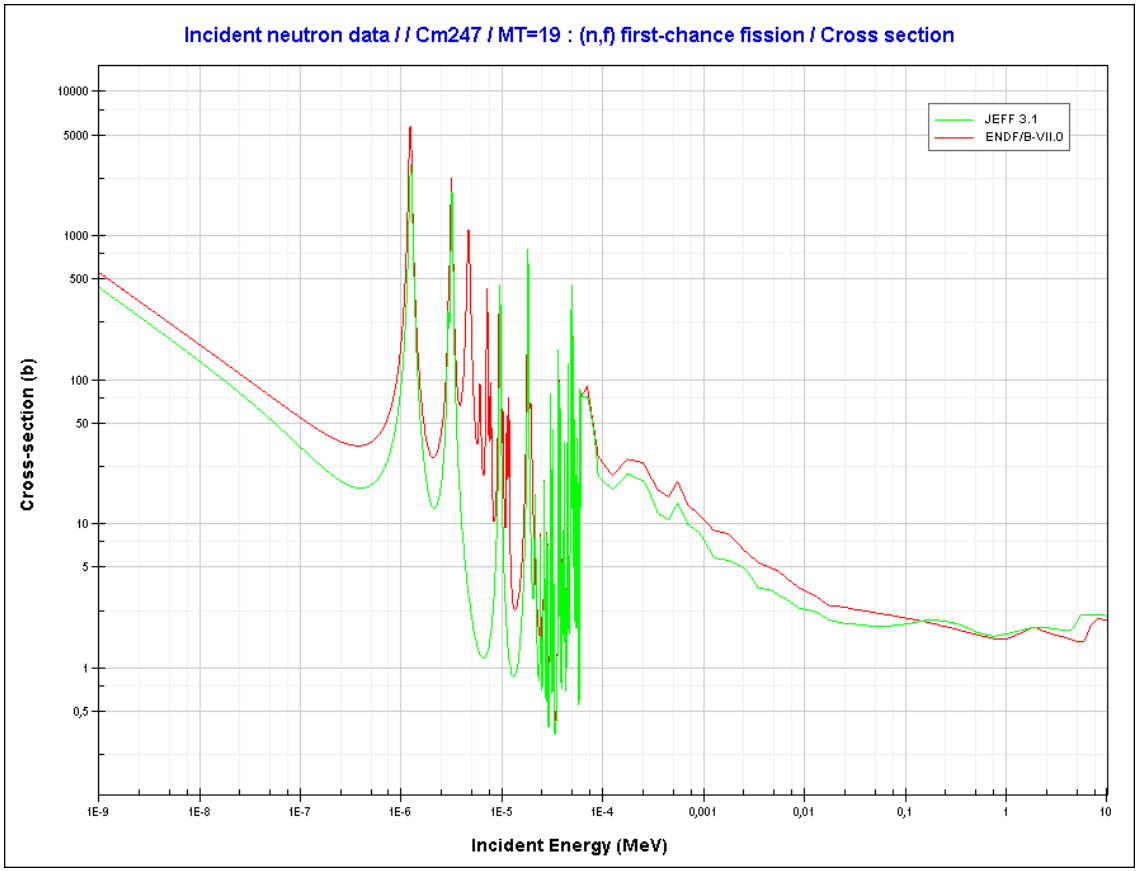
^{245}Cm (n,f) first-chance fission

Comparison of Existing Data

Cross-section at $E_n = 25$ *meV*

(ENDF/B-VII.0)
111.35 b

(JEF 2.2)
81.83 b

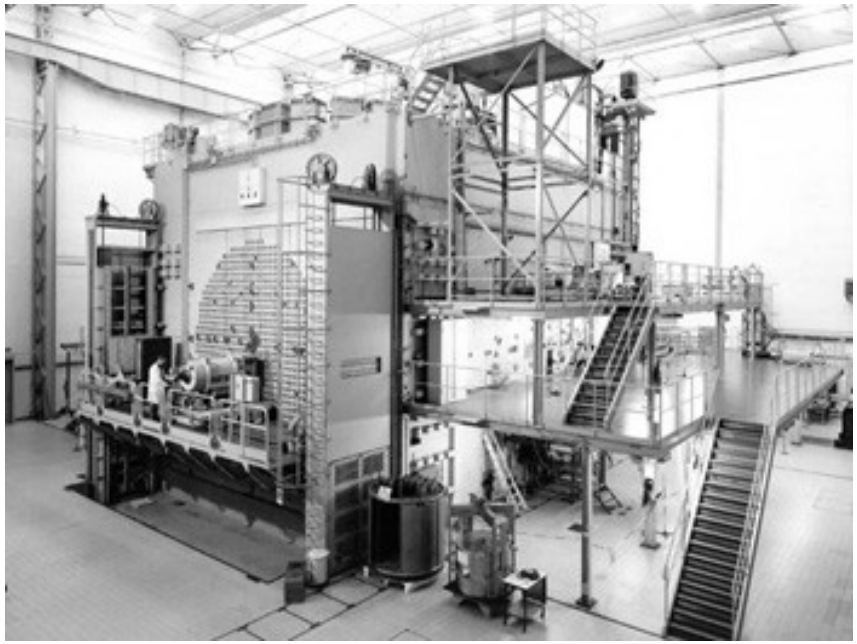


^{247}Cm (n,f) first-chance fission

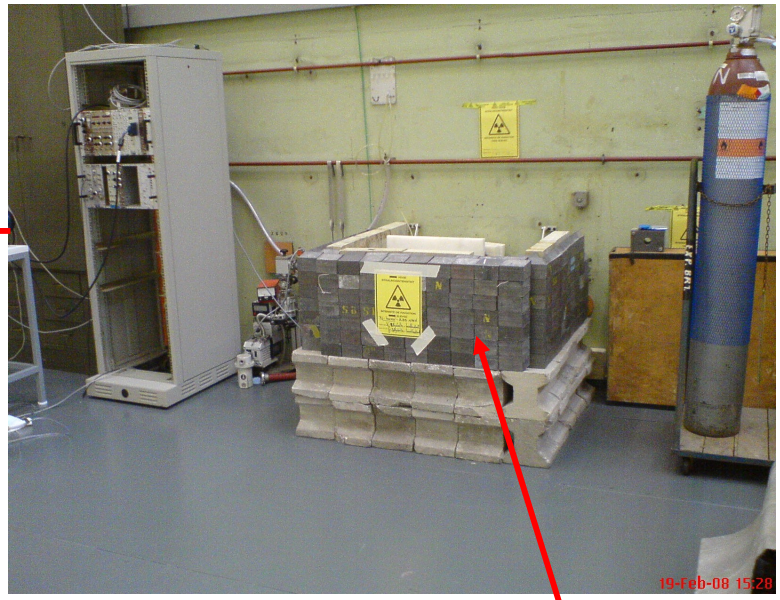
Measurements @ BR1

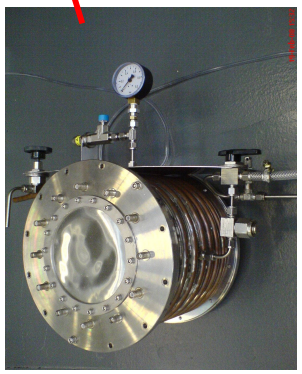
- **BR1 (research reactor)**

  - In operation since 1956
  - Fuel: natural U
  - Moderator: graphite
  - Cooling: air
  - 4MW thermal power
  - Operation:
    - Daily basis (7h/day)
    - 700kW (1MW)



Experimental Setup





Location:

BR1 B-side, Z59 channel

Detector:

FG ionization chamber

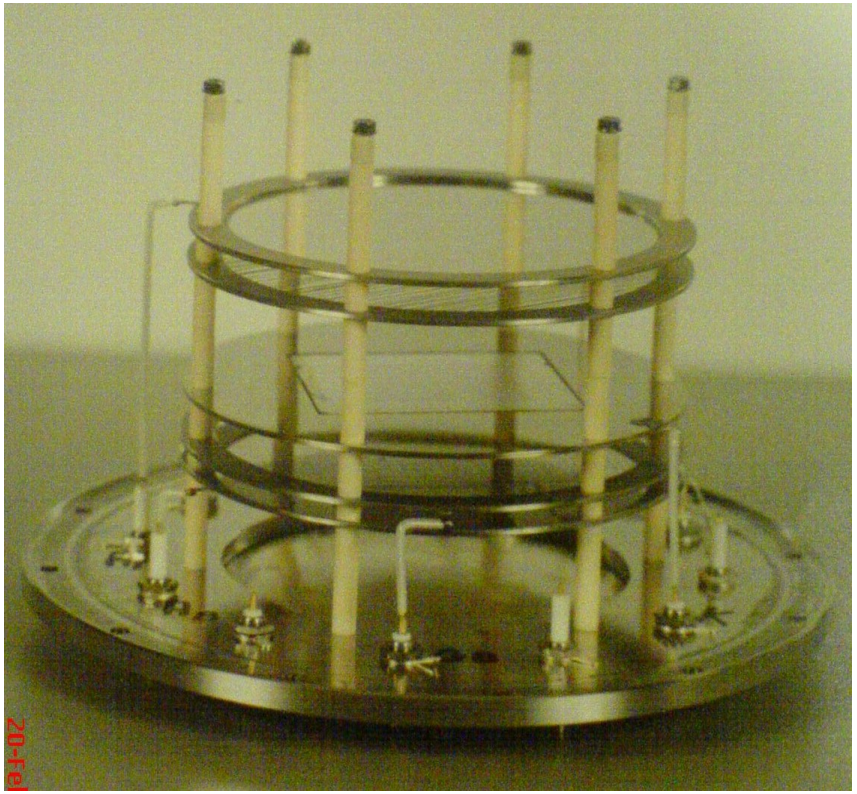
Detection System

Frisch Grid Ionization Chamber

- Gas mixture:

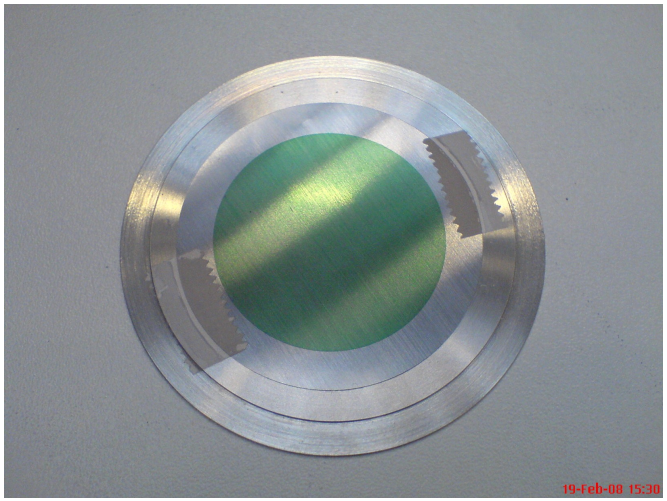
  CH_4 (10%) and Ar (90%)

- Designed for *back-to-back* measurements
- Samples mounted on the Cathode
- Frisch Grids for C / A electric fields separation
- Collected signals from Anodes

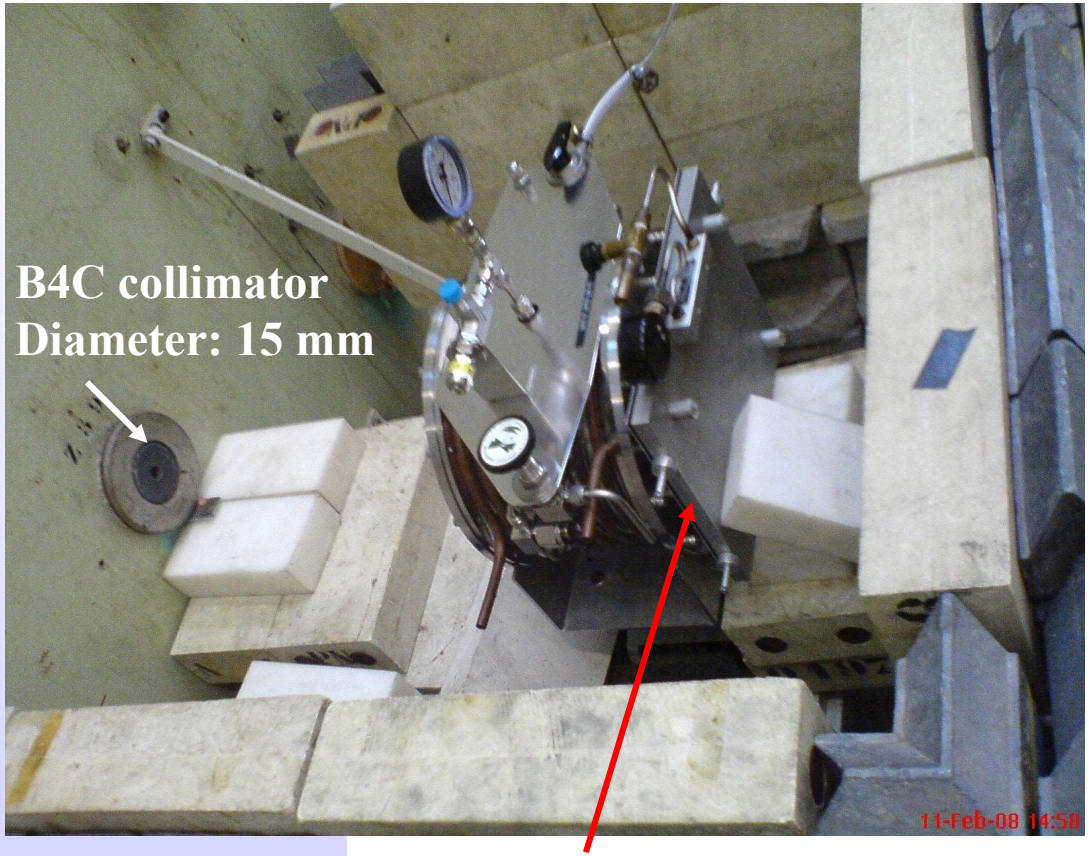


Samples to be measured

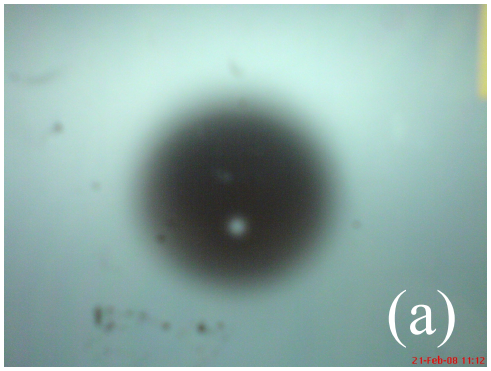
- First test measurements :
  - $^{10}B(n,\alpha)$
- Calibration measurements:
  - ^{235}U
- Measurements of interest:
  - ^{243}Cm, ^{245}Cm, ^{247}Cm

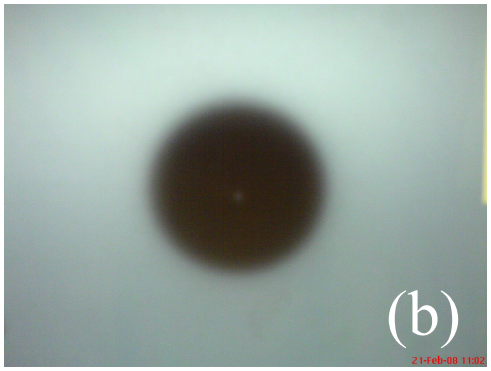


Collimation. Detector Alignment



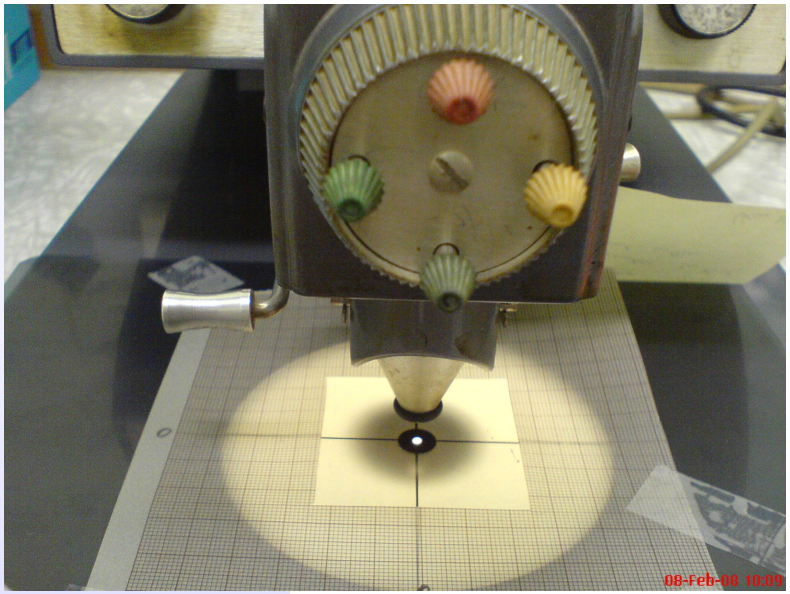
Neutronography device:
Gd plate followed by a photographic film

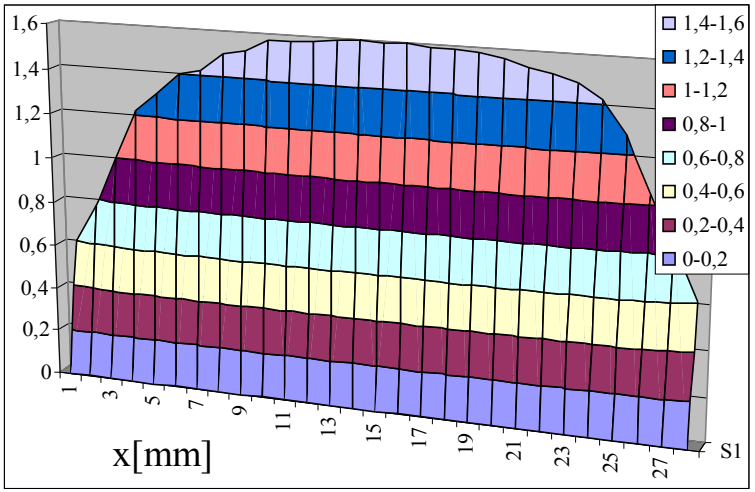


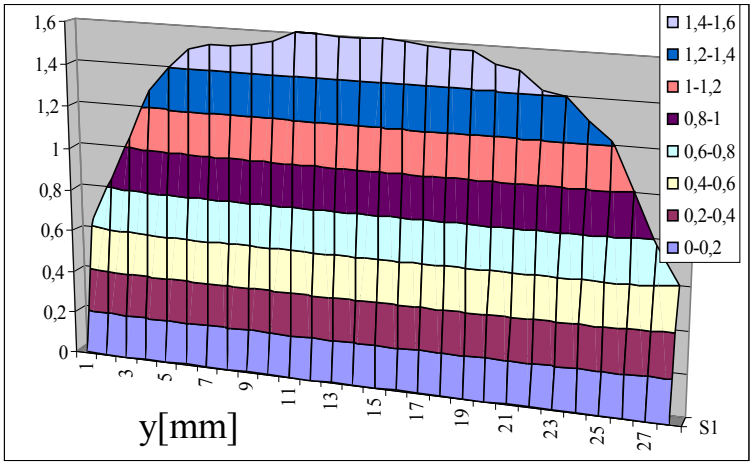


beam profile before (a)
and after (b) alignment

Beam Homogeneity



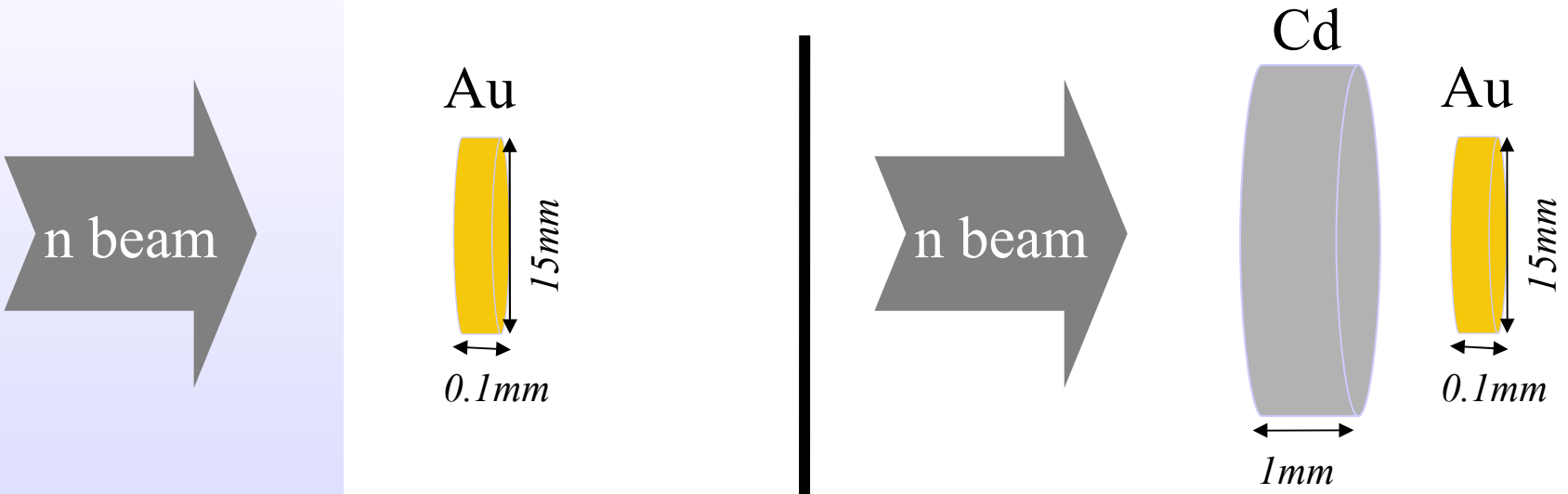




Densitometry analysis of the photographic film:
homogeneous beam on the target surface

Estimation of Beam Flux (I)

- Au activation - absolute n-flux measurement



- irradiation time: 7 hours
- neutron-flux: ~5.8x10^5 n/cm^2 s (thermal & epithermal)

- irradiation time: 7 hours
- neutron-flux: ~4.7x10^4 n/cm^2 s (epithermal)

Estimation of Beam Flux (II)

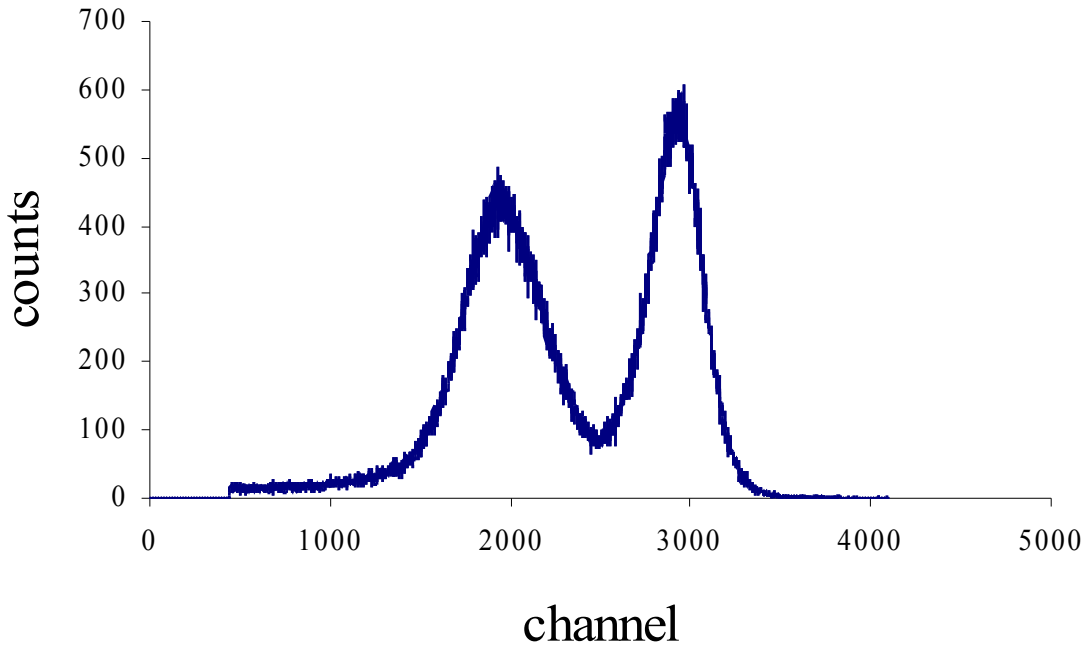
- $^{235}U(n,f)$ – cross section measurement

- well known σ

- measurement with & without n_{th}- filter

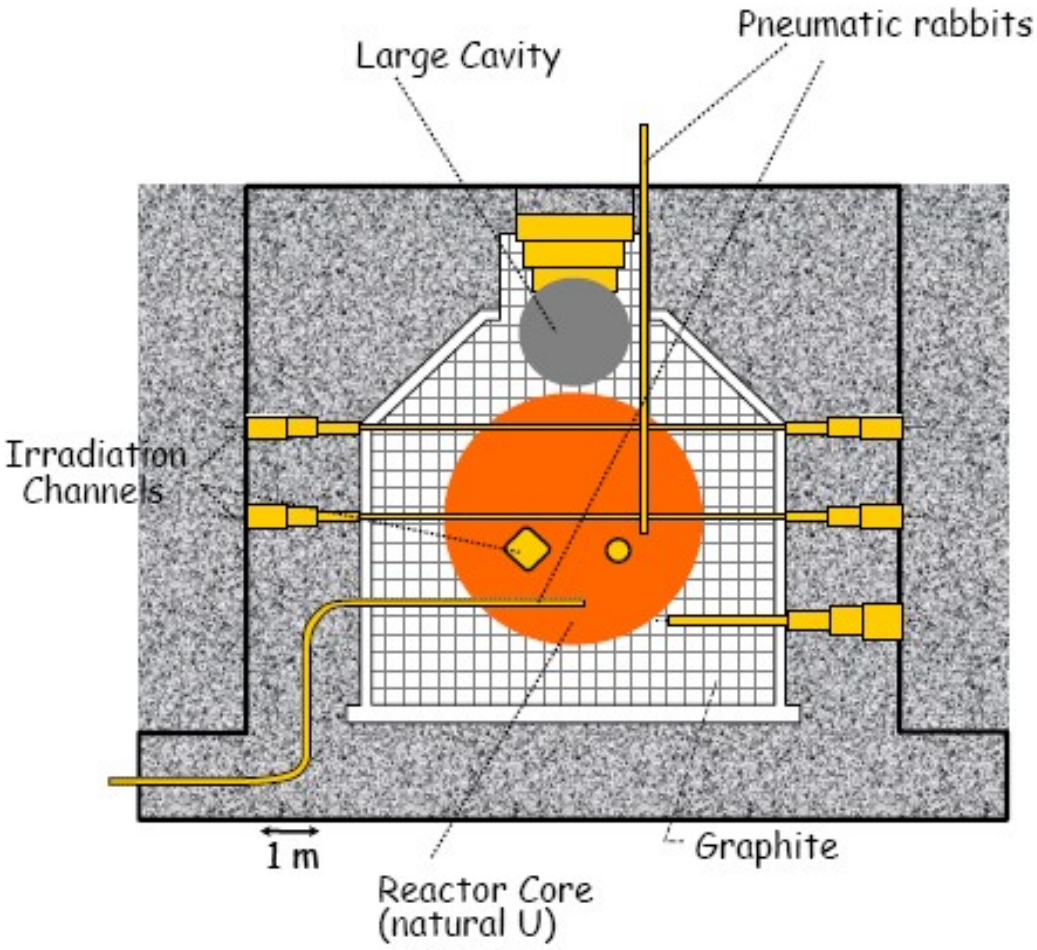
⇩

$\Phi n_{th} / \Phi n_{eth}$



Improving Φn_{th} / Φn_{eth} ratio

- moderating epithermal neutrons in C-cylinders mounted in the irradiation channel



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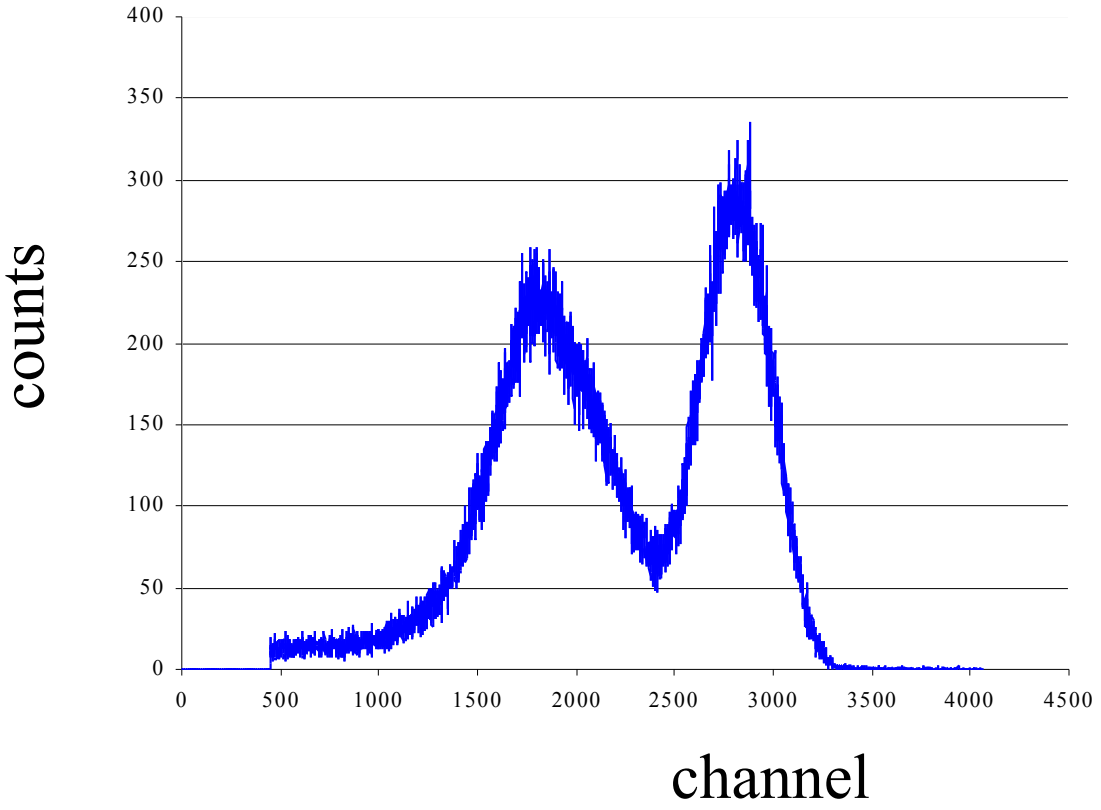

Challenges

- High counting rates due to the α-decay

Sample	^{243}Cm	^{245}Cm	^{247}Cm
Activity	3.17 MBq	4 MBq	1 MBq
Expected counting-rate α's	>1 500 000 cts/s		
Expected counting-rate FF	< 1 cts/s		

- Online data filtering (*idea: filter based on digital pulse analysis DPA*)

Conclusion: It is so simple!

We only need to produce the reactions of interest…

- … and maybe to use a faster detector…
- … and a fast digitizer …
- … and some DPA methods …
- … …

pulse analysis is trivial:

"I came as quickly as I could."

Acknowledgement

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Fission fragments in $^{235}U(n,f)$